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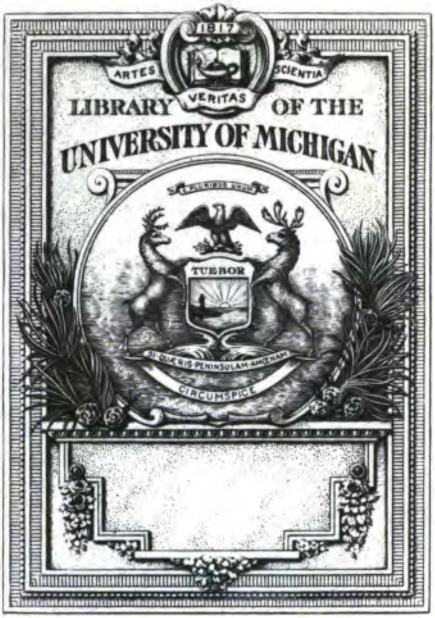

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International Fisheries Exhibition
LONDON, 1883

224

FISH DISEASES

BY
Thomas Henry
PROFESSOR HUXLEY
H.M. INSPECTOR OF SALMON FISHERIES FOR ENGLAND AND WALES.

LONDON
WILLIAM CLOWES AND SONS, LIMITED
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1883

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International Fisheries Exhibition,
LONDON, 1883.

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CONFERENCE ON TUESDAY, JULY 3, 1883.

The MARQUIS OF HAMILTON in the Chair.

ON FISH DISEASES.

THE title of the present paper is, I am sorry to say, far too large for its contents, for I propose to speak, not of fish diseases in general, but of that particular malady which attacks freshwater fishes, occasionally assumes the dimensions of a very formidable epidemic, and, in one of its forms, the so-called "Salmon disease," is too well known.

At the first onset of this disease, small whitish patches make their appearance on the skin of the fish. The smooth integument of the top of the head, or of the end of the snout, is a very usual locality, but the adipose fin, and the axillæ of the paired fins are also among the first parts to be affected. If there is an abraded or wounded surface, the disease is pretty sure to attack it, but the invasion of the malady is in nowise dependent upon the pre-existence of an injury. In severe cases, the mischief rapidly extends, until sometimes almost the whole body is covered with an ashen grey coat, which completely hides the scales. On brushing off the crust, however, the scales are usually found undisturbed. In the scaleless parts of the skin, sloughing soon sets in, and deep burrowing sores are formed. On the head, the cranial bones may be exposed, and the fins are eaten away, and become ragged. Very often one or both gill-covers become partially glued down to the shoulder, and the gill-openings obstructed, but I have never yet been able to meet with any sign of disease on the gills themselves. This is contrary to common belief, but I can only say that such is my experience. On the other hand, the disease frequently invades the cavity of the mouth, and often more or less destroys the membranous veil which lies behind the teeth, and plays a curious part in respiration. Thus, although, so far as I have been able to observe, the respiratory organs are not directly attacked, the performance of the respiratory function may be very seriously obstructed.

If the mucous membrane lining the mouth be reckoned with the integument, of which it really is a part, it may be said that the affection under discussion is strictly a cutaneous disease, comparable to ringworm among men. However badly a fish may have been diseased, there is no trace of the affection in the abdominal cavity or in any of the viscera, and the muscles and deep-seated bones appear healthy. Some say that the liver is enlarged and soft, but I have seen the liver quite healthy in very severe cases.

The fish appear to suffer considerable irritation from the disease; but how far this is a primary symptom, and how far it results from the entanglement of multitudes of minute grains of sand in the fluffy coat of the diseased skin, is uncertain. Badly diseased fish in aquaria, the water of which contains no suspended particles of sand, do not show signs of any particular irritation.

The mortality among salmon, sea trout, and freshwater trout caused by this disease is very considerable. In the last five years from 2000 to 4000 diseased fish have been taken out of the Tweed, and a like number out of the

Eden every year. As many as 600 diseased salmon were taken out of the Lune, which is but a small river, last year.

The course of the epidemic has been very remarkable. It began to attract attention in the River Eden in 1877; shortly afterwards it appeared in the Tweed, and it has remained ever since in great but variable intensity in those and adjacent rivers. On the east coast, a few cases have appeared in the Coquet, but none have been noticed in the Wear. Among fresh-run salmon it is almost unknown on the Tyne, though it commonly appears on kelts and on dace. But it has never taken an epidemic character in this river nor in the Tees. In the Yorkshire Esk fifty diseased fish were taken out in 1882, but there has been no serious epidemic. Two or three diseased salmon were taken out of the Ure last season, but southward of this I have no information of any disease in the rivers of the east coast.

It may be said, then, that there has been practically no epidemic outbreak in the eastern rivers south of the Tweed. On the west coast of England the state of affairs is totally different. Since 1879, the disease in its epidemic form has made its appearance more and more to the south, until last season it broke out in the Usk and in the Wye.

These facts are very remarkable and very important. For if, as I believe to be the case, the morbid affection the skin is wholly extirpated when the salmon descend to the sea, it is not possible that the disease should be propagated from one river to another by the immigration of fish from an infected into a healthy river. It is quite possible that the fungus which, as we shall see, is the cause of the disease, might be transferred from an infected to a healthy river by birds, but the evidence in the Tyne and in the Usk is conclusive that the disease has long existed to a slight extent in these rivers, so that the theory of transportation is superfluous.

Again, the facts are not favourable to the supposition that either pollution or overcrowding has much to do with the matter. The Clerk of the Kent, Bela, Winster, Leven, and Duddon district reports this year that, in the River Duddon, there is no obstruction between the sea and its source, and that it is perfectly free from pollution. The river is to a great extent unpreserved, and there has been no overcrowding. The disease was not noticed till last year, 1881–2, when the watchers removed about forty fish. The Leven is an outlet of Lake Windermere. The only possible source of pollution is the sewage of the little town of Bowness, which falls into the great body of water of the lake, and may be disregarded. Disease was unknown in the Leven until the last season, when it suddenly became the most infected river of the district.

A very competent authority, Mr. Berrington, Chairman of the Usk Board, informs me that the disease has always been known to occur occasionally, especially in late kelts —rarely in fresh-run fish; sometimes in dace, trout, and young salmon. In 1881, however, it was carefully looked for, but no trace of it could be found. Nevertheless, in January and February, 1882, it was unusually prevalent in spawning salmon. In the end of March and in April, when the river contains the smallest number of salmon, a violent epidemic broke out among the trout, and lasted through May and June.

The salmon ran up the river early this year; and, in April, numerous diseased clean fish were observed. Between the first week of July and the end of October, the disease entirely disappeared; but, in November, a violent outbreak occurred, trout and salmon, spawned and unspawned, dying in large numbers. This epidemic lasted until the middle of May of this year. It then began to diminish; salmon could be watched recovering from the disease, and by the beginning of June it had almost disappeared, although the river was very low. In the previous year freshes had no effect in diminishing the disease.

I attach great weight to these careful and precise observations, and I shall have something to say about their bearing by-and-by. They prove conclusively that, even while the fish remain in fresh water, diseased salmon may completely recover, and they would leave no doubt in my mind that the epidemic has no necessary connection either with pollution or with overcrowding, even if this point had not been settled already. Mr. Byers, formerly surveyor in the Government service in British Columbia, told the Commissioners who inquired into the salmon disease in 1880, that he was on the Harrison River, one of the tributaries of the Fraser, in that dependency in 1861, and that he there saw thousands of diseased salmon. The disease has also been observed in the Castries rivers in Siberia. Yet neither in British Columbia nor in Siberia can the rivers be much troubled with pollution from high farming or industrial occupations. It is true that Mr. Byers attributes the disease to overstocking, but this is a mere guess; and it is negatived by the facts adduced before the same Commissioners by Sir James Maitland, who kept 12,000 Lochleven trout, varying in weight from half a pound to five pounds, from November to March 1878-9, in three ponds, each about 300 feet long, 45 feet wide, and 6 to 13 feet deep, without loss of more than 1 per 1000. Another very singular fact which has been brought to light by observation, though it certainly sounds paradoxical, is that even a violent epidemic of disease, continued for several years, does not diminish the productiveness of a river. The Tweed has suffered as severely as any river during the last five years, and yet the catch of salmon in 1882 (8,808) was more than double what it was in 1879 (3,472).

I have been favoured this morning by Messrs. Forbes, Stuart & Co., of Lower Thames Street, with the following returns, which show that, disease notwithstanding, the supply of salmon from the rivers of the United Kingdom to London, in the month of June just past, was far in excess of that in the same months in the five preceding years.

ARRIVAL OF SALMON IN LONDON IN JUNE FOR THE LAST 5 YEARS IN BOXES.

	1879.	1880.	1881.	1882.	1883.
Scotch	1,541	1,847	2,544	3,605	6,643
Irish	1,553	1,864	1,995	1,243	3,073
English	409	756	524	848	760
Berwick	132	182	197	198	245
Dutch	113	9	45	7	39
Swedish	26	122	..	52	28
Norwegian . . .	131	175	178	80	124
Total	3,905	4,955	5,483	6,033	10,912

Such are the most important phenomena presented by salmon disease in this country. Naturally its rise and progress have excited considerable alarm, and the usual swarm of empirics have propounded their dogmas about the causes and their specifics for the cure of the disease.

Nothing is more curious than the readiness of people who dare not undertake to mend a meat-jack because they know nothing about machinery, to give decided opinions about the causes and the method of dealing with natural occurrences, the mechanism of which is infinitely more complicated than that of the culinary apparatus—while their ignorance of even the elements of the problem is absolute.

Surely it does not want any science, but only a little common sense, to see that the first step in a case of this kind is to find out the exact nature and causes of the phenomena over which we wish to exert a control. The foundations of such knowledge in respect of the salmon disease were laid by the late Mr. Stirling, in a series of papers which appeared in 1878 and 1879, and I have been trying for the last two years to raise the superstructure, which, however, is, as yet, by no means complete.

If the fluffy whitish coat which is so characteristic of the diseased skin—and is sometimes tenacious enough to be stripped off in flakes like wet paper—is examined microscopically, it is seen to consist chiefly of a tangled mass of fine filaments, on an average about $\frac{1}{2000}$th of an inch in diameter, which are at once recognisable as the stems (or *hyphæ* as they are technically termed) of a fungus (*Saprolegnia ferax*), similar to those which are known as "moulds," and which commonly grow upon, and obtain their nourishment from, decaying organic bodies. The so-called "blue mould" (*Penicillium glaucum*), which attacks all sorts of dead organic bodies from cheese and jam to old shoes, is a familiar example of these plants, which, however troublesome to housewives, play a very important part in the economy of nature as scavengers, by whose agency dead and decomposing organic bodies are cleared away. All the fungi which thus prey on dead animals and vegetables are known as *Saprophytes*, a term which may be pretty nearly paraphrased by "rot-plants."

But there is a large number of these moulds which are not saprophytes, but parasites; that is to say, they attack living animals and plants, and in many cases destroy them with great rapidity. The silk-worm culture is sometimes ruined by the so-called "muscardine" disease, caused by a mould, the *Botrytis bassiana,* which enters the body of the silk-worm and destroys its substance.

In some autumns, our common domestic flies are destroyed in prodigious numbers by another curious mould, the *Empusa muscæ.* Even mankind are not free from the attacks of fungi, as in the ringworm of children's skins. And as to plants, multitudes of destructive epidemics of which the smut of wheat and the potato disease are the most notorious, are produced by parasitic fungi of various kinds.

As a general rule, fungi are either saprophytes or parasites—that is to say, they live habitually either on dead or living organic bodies.

Now the *Saprolegnia ferax* which, as we have seen, forms the cottony covering of the diseased salmon skin, is habitually a saprophyte, especially found on dead insects; and when it was first discovered to be a constant concomitant of the salmon disease, there was very good reason for suspecting that it might be a saprophyte, preying on the dead tissues of the skin destroyed by a precedent affection, and not a parasite, the presence of which was the true cause of the destruction of the tissues.

When I addressed myself to the study of the disease two years ago, therefore, I endeavoured in the first place to obtain conclusive evidence on these two points. 1. Is the saprolegnia of the salmon the cause or only the concomitant of the disease? Is it the real enemy or only a camp-follower? 2. If the *Saprolegnia* of the salmon disease is a true parasite, is it identical with the *Saprolegnia* already well known as a saprophyte?

It was for this purpose that I went to Bettws-y-Coed, in the winter of 1881, in order to study, on the fresh fish, the nature of the epidemic of salmon disease which had broken out in the Conway; and I soon obtained the evidence I sought, for by examining the margins of moderate-sized fresh patches on the heads of salmon, it was not difficult to demonstrate that the patch of fungus constantly extends at the periphery by sending out fresh hyphæ into the healthy epidermis, which it breaks up and destroys; at the same time, it drives into the subjacent vascular true skin hyphæ which play the part of rootlets; these, ramifying in the superficial layer of the true skin, give rise to sloughing. If a single strawberry-plant is set in the middle of a bed, it will send out runners in all directions, and these will strike root into the soil wherever they go until the whole bed is covered. The *Saprolegnia* patch grows in a somewhat analogous fashion, but its "runners" and "roots" destroy the living tissues in which they are lodged.

These observations left no doubt in my mind that the *Saprolegnia* is the cause and not a mere accompaniment of the salmon disease—that the latter is in fact what pathologists term a *mycosis*. And with respect to the other point, namely, the identity of the parasitic with the saprophytic *Saprolegnia*, I found it easy enough to obtain equally conclusive evidence.

If the salmon *Saprolegnia* was the same as that which commonly grows on dead insects, it is obvious that one ought to be able to sow dead insects with it and raise a crop of the fungus on them; and in fact nothing is easier than to do this. Fill a clean tumbler three parts full of clean spring water, and provide it with a loose paper cover; then catch two or three common house flies, kill them by squeezing them gently without breaking the tough skin in which the body of the fly is enveloped, and rub them softly once or twice over a patch of diseased skin. Drop the flies into the tumbler, and they will float at the top on account of the large quantity of air which their bodies contain.

If the bodies of the flies are examined at this time with a good magnifying glass, nothing will be seen but a few threads representing the hyphæ of the saprolegnia, which have been entangled by their legs and bodies.

By way of a check experiment it is advisable to put two or three flies caught at the same time, and treated in the same way, into a tumbler of the same water, but taking care that they are not brought into contact with the diseased skin. In this tumbler, covered as before, the bodies of the flies may remain for weeks, and gradually decay without showing any trace of fungus. Sometimes, however, *Empusa,* and sometimes, *Penicillium* or *Mucor* may make their appearance. In the first case, the germs of the *Empusa* were certainly in the body of the fly when it was killed. In the second, they were very likely on it, but may have been imported from without. In no instance that has ever come under my observation, has *Saprolegnia* made its appearance in flies treated in this way. This is singular, considering that it is often stated that *Saprolegnia* appears regularly on flies thus treated ; but I imagine that this is the case only when pond or river water is used.

The phenomena presented by the flies which have been brought into contact with the diseased salmon skin are very different. In about four-and-twenty or, at most, six-and-thirty hours, that part of the body of the flies which is in contact with the water presents a more or less extensive coating of fine, short, white hyphæ, set so close together that they look like a close-cropped turf. These filamentous hyphæ grow with great rapidity, and spread more and more widely. Their increasing weight gradually drags the fly's body down, until it becomes completely submerged, and at length sinks to the bottom, invested by a white ball formed by the hyphæ, which radiate on all sides from its body.

Microscopic examination now shows that these hyphæ perforate the tough cuticle of the fly, and ramify in the interior of its body, destroying and appropriating the tissues. On their outer free ends, on the other hand, a large number of the hyphæ are terminated by a sort of fruit (*sporangium*) in which the minute bodies (*zoospores*) which play the part of seeds or germs are formed, and from which they are eventually discharged. The comparison of the characters of the sporangia and spores with those of *Saprolegnia ferax* will leave no doubt that the fungus thus transmitted from the fish to the fly is of that species.

In order to complete the chain of proof, it was necessary to give the disease to fish by infecting them with *Saprolegnia* from the insect. As I had very little time to devote to the experiments requisite for this purpose, I requested my friend Mr. George Murray, of the Botanical Department of the British Museum, to join with me in making them. Our first attempts yielded negative results, but, on the 2nd of March, 1883, Mr. Murray rubbed a saprolegnized fly on the left flanks of two healthy dace, at a spot about the middle of the length of the body.

"On the 5th of March," Mr. Murray reports, "each of these fish had a small tuft of what was afterwards found to be *Saprolegnia ferax* growing on the region of inoculation, and, by the 10th of March, it had grown into a large patch."

One of these fish escaped. "The other died on the 16th of March, its body being nearly covered with a luxuriant growth of *Saprolegnia ferax*." Two other fish similarly infected died, the one in ten days and the other in fourteen days. This, so far as I know, is the first direct evidence that the *Saprolegnia* of the salmon disease is capable of being transmitted from dead insects to living fish of other kinds.

Combining these observations with those made on the epidemic among carp by Unger in 1844, and with those of Stirling on the fish in the Ightham ponds, I begin to doubt whether any other fungus than *Saprolegnia* attacks fishes. A distinction is often drawn between the "aquarium fungus" and *Saprolegnia*. But within a few days of the opening of this Exhibition, the trout and char in the freshwater tanks were largely attacked by "aquarium fungus," and I took the opportunity of subjecting fresh specimens to careful examination. I found it to be all *Saprolegnia ferax*, and I could cultivate it on flies just as well as the salmon *Saprolegnia*. As yet, I have met with no satisfactory evidence that the integument of fishes is attacked by anything but *Saprolegnia*.

The *Saprolegnia* is essentially a freshwater organism, which dies as soon as an infected fish reaches salt water. As, however, it is only the exposed part of the fungus which comes into contact with the sea water, it was possible that the hyphæ, which are embedded in the true skin, might retain their vitality during the sea life of the fish, and make their appearance at the surface on its return to fresh water. And, when I made my first report on the disease, I thought it possible that the key to the mystery of the appearance of the disease in fish just returned from the sea might lie here.

But this does not appear to be the case. Mr. List, the Chief Constable of Berwick, has been good enough, at my request, to repeat some experiments which he had formerly made upon the effect of confining diseased salmon and sea trout in coops in the tideway of the estuary of the Tweed at Berwick; and, in June 1882, he sent me two sea-trout which had got completely well under these circumstances, though signs of the situation of the patches of disease remained. Careful examination of the skin in these regions by means of sections prepared for the microscope, revealed no trace of the fungus; so that it would seem that the parasite is completely rooted out by the sea water.

In a river which remains year after year the seat of epidemic salmon disease, therefore, *Saprolegnia* must be permanently resident there, in some shape or other; and the fish which ascend are infected by this stationary store of the fungus.

In the experiments which have been described, the fungus has been brought into direct contact with the fly or the fish to be infected; but this is not at all necessary. In a full-grown specimen of the fungus, the great majority of the hyphæ end in sporangia, and one of these may contain a hundred or more minute zoospores. These, when ripe, are ejected from the sporangium, and each is propelled by a pair of cilia through the water. By these means, and by the currents in the water, these zoospores may be drifted a long way, and if any one of them reaches a fish, it may germinate, penetrate its skin, and give rise to the disease.

The quantity of zoospores which may be produced from a mass of *Saprolegnia* no larger than that which covers an ordinary fly, is prodigious, and a few diseased salmon might thoroughly infect the waters of a considerable stream.

But it is possible that no trace of *Saprolegnia* may be present either on living or dead organic bodies in a mass of fresh water, and that no *Saprolegnia* may be imported from without; and that, nevertheless, after a time, these bodies may be attacked by the fungus. This arises from the circumstance that *Saprolegnia ferax*, like other *Saprolegniæ*, has two modes of reproduction, the one sexless, by zoospores, such as have been described, the other sexual, by *oospores*, which answer to the seeds of ordinary plants. Reproduction by zoospores is the ordinary and constant process, that by oospores takes place with less regularity. I have never seen an oospore upon *Saprolegnia* growing on salmon, and there are some sources of difficulty in the identification of these bodies which lead me to entertain a doubt whether any other observer has done so. Mr. Murray, however, has found them abundantly on *Saprolegnia* growing on dace. *Saprolegnia* may be cultivated on flies for many months without the appearance of oospores, and then, in a solitary specimen, they may present themselves in great numbers.

These oospores are spherical bodies provided with a thick coat. Once formed, they pass into a quiescent condition, in which they may remain for many months. Sooner or later, however, they awake to new activity, and their contents either break up into zoospores which are set free and roam about until they reach an appropriate nidus, or grow directly into a *Saprolegnia*. Thus it is possible that the *Saprolegnia* in a pond or stream, having given rise to oospores which fall to the bottom and remain quiescent, may die away and leave no apparent trace of its existence, and yet, months afterwards, the oospores may germinate, and in a few days give rise to an abundant crop of the fungus.

It is not only possible, but probable, that there are yet other forms totally different from the ordinary *Saprolegnia*, under which the mould may continue its existence. The recent investigations of Brefeld on the torula condition of many fungi (*Ustilago, Tilletia*), known hitherto only as parasites on plants, are very significant in connection with this question.

Permit me now to sum up, in a few propositions, the present state of our knowledge respecting the salmon disease:—

1. The sole cause of the disease is the fungus *Saprolegnia ferax*, which burrows into and destroys the skin of the fish.

2. This fungus habitually lives on dead organic matter, and exists only in fresh water.

3. The *Saprolegnia* is propagated by zoospores, oospores, and possibly also in other ways. The zoospores and the oospores give rise either to the saprophyte *Saprolegnia*, which lives at the expense of dead organic matter, or to the parasite *Saprolegnia*, which lives at the expense of living freshwater fishes.

4. The zoospores of the *Saprolegnia*, grown on fish, attack dead flies, and the zoospores of the *Saprolegnia*, grown on flies, attack living fish.

5. It follows, therefore, that the existence of the cause of salmon disease, or, to speak more generally, of the integumentary mycosis of freshwater fishes, is independent of the existence of fishes; and consequently that the extirpation of all the diseased fish in a river does not involve the extirpation of the cause of the disease in that river.

6. There is reason to believe that the *Saprolegnia* exists

in its saprophytic form in most fresh waters, and that it attacks the fish of most rivers occasionally. In other words, the mycosis of freshwater fishes is a widespread sporadic disease.

7. That which it is now desirable to ascertain, is the nature of the influences under which the sporadic disease suddenly assumes an epidemic character.

On this point we have very little light at present, for although there is some reason for thinking that deficient oxygenation, whether produced by overcrowding or otherwise, may favour the development of the disease, and though it is possible that some kinds of pollutions may favour it, yet the disease sometimes becomes epidemic under conditions in which these two predisposing causes are excluded; and it does not always appear when they are present.

8. Epidemics subside spontaneously, though the fish remain in fresh water.

9. The productiveness of a salmon river is not necessarily interfered with by even a violent epidemic.

The last three propositions indicate the moral of my paper—which is to make sure that you know what you are about before meddling with the salmon disease. Until the causes which convert the sporadic into the epidemic disease are known, all interference is mere groping in the dark; and when they are known, it will be a great question whether the preventive measures adopted are worth their cost.

Fishery doctors at the present day remind me of human doctors in my youth—they were always for doing something. I remember one of my teachers laid down the notable maxim, "when you are in doubt, play a trump," and I should think that those of us who have followed his advice, in the last forty years, must have largely added to the bills of mortality. Our fishery doctors are of the same mind as my friend. They are (or at any rate ought to be) very much in doubt, and yet they continually want to play trumps in the shape of stringent regulations and restrictions. If I might tender a piece of advice, I would say—don't.

DISCUSSION.

Mr. FOLLETT asked why it was the diseased fish rose to the surface of the water, he referred especially to gold fish in artificial ponds.

Professor HUXLEY said there was probably an increase in the amount of air in the air-bladder, and very likely in the viscera also produced by incipient putrefaction.

Dr. SPENCER COBBOLD, having paid some attention to parasites for a great many years past, had come there hoping that Professor Huxley would open up the whole subject, though contemplating its vast extent, he felt that even he would find a difficulty in compassing it. This not having been done, he would say a few words on the parallelism between the *rôle* played by external and internal fungi which might throw a little light on the general subject. It was found on examination that certain fishes were covered with Saprolegnia, and when they were dissected they found no trace of internal parasites. In such cases where death had supervened it was evidently due to the presence of Saprolegnia alone, but in other cases a number of internal parasites were also found; and when they took into consideration the fact that the *rôle of* the internal parasite was so similar, with regard to the irritation it created to the external, the only difference being that the irritation set up by the internal parasites was in the muscles and viscera, it was impossible for any logical mind to deduce any other conclusion than this, that the internal parasites were sometimes associated with the external in the production of disease and death. On the other hand there were some instances where no external parasites were found, but there were hundreds of thousands of small parasites of the entozoa character, which brought about the same fatal issue. In illustration he might mention that a few years ago one particular kind of parasite, which he he had shown to the Prince of Wales and Prince Napoleon the night before, killed hundreds and thousands, and, as one French author said, hundreds of thousands, of coarse fish. Professor Huxley had shown in a most interesting manner that the germs of Saprolegnia might be propagated by other bearers than the salmon itself; and here again he would point out that there was a parallelism with the internal parasites, they being conveyed by bearers or intermediate hosts. The adult parasite required a change of hosts, passing from small insects to the fish. That was the case with one which was very common in the perch, and other coarse fish, and the higher parasites or the larger ones, the *cestodes*, were also propagated through the means of intermediary bearers. It might interest the audience if he were to state a curious fact in connection with parasites in fish as he might not have another opportunity of doing so, owing to his numerous engagements. Whilst showing a specimen of a large ligula, so common in fresh-water fish, to Prince Napoleon, he reminded him that they were what were called in Italy "Maccaroni piato," and were constantly eaten there as a delicacy, being supposed to be fleshy growths inside of fish. Fortunately it might be hoped that this particular parasite would be destroyed with even the very slight cooking, and even if not cooked, there was no reason to suppose that the ligula would be transformed into a higher form of parasite in the human body, although there was a form found in these fish which was transformed into the well known *bothriocephalus latus* which was well known in Russia and sometimes in Ireland.

Mr. MARBER wished to draw Professor Huxley's attention to a case which had come under his notice this year in connection with a small river in Scotland. This year there were a number of fresh-run salmon in the river in the month of March which had never been known before by the oldest inhabitant. After they came there were a great number of diseased fish found with this fungus, that disease never having been known to his knowledge in the river before. He should like to ask if any reason could be given why these fresh-run salmon, which never before appeared in the river so early, had come there and brought this disease immediately after.

Professor HUXLEY said the salmon were quite innocent of bringing the disease there; there was no doubt they caught it in the river.

Mr. MARBER said the river was prolific in salmon, but they were always very light. They were never known to arrive so early before, and these were not native salmon of the river.

Professor HONEYMAN (Canadian Commissioner) said the subject of parasites had been brought to his attention for some time past, and not long ago, when preparing the collections on the other side of the Atlantic for the Exhibition, he one day bought from a countrywoman a very fine trout, which he thought would be suitable to exhibit, and took it with him to the Museum. A friend who took great interest in subjects of the kind—one of the foremost investigators in fish anatomy—informed him that he had just discovered that some fish he had bought were full of parasites, and that he had informed the health officer of the circumstance, and the sale of the fish had been stopped. On examination he found that the one he had purchased was similarly affected. The people who came in from the country to sell these fish felt annoyed at the sale being stopped, and very naturally so, but the health officer went fully into the subject, and the result was that a formidable collection of parasites was exhibited; the consequence was that many people got exceedingly alarmed, and consulted him about it. He told them if they went inquiring into everything they ate they would never eat anything at all. The best way was not to take alarm at the results of scientific investigation, but to go on eating, and not ask any questions. He must say he had never heard of anyone the worse for eating fish, even if they did contain parasites. They often heard of all the ills that flesh was heir to, but, judging from what they had now heard, and from the appearance of a specimen in a glass jar on the platform, there were many ills which fish were heirs to as well, and there were certainly a most formidable collection of these parasites shown by Dr. Cobbold.

Mr. MACKENZIE wished to ask Professor Huxley if he had taken into consideration the question of preventing the distribution of *ova* from infected rivers. It seemed to him that was a case where, perhaps, the heroic remedy would be the only proper one until light was thrown on the modes in which this disease was propagated.

Mr. SIGGINS said that during last April he spent a few weeks at Ramsgate, and in conversation with the fishermen there he remarked that the mackerel were unusually large, but that they were the worst in flavour he had ever met with; their reply was that the fish were out of season, and no fisherman would ever think of eating mackerel at that time of year, but if he looked under the skin before they were cooked he would find a large collection of parasites. It occurred to him that, probably, the fish which were diseased were the fish out of season. There was a season for all things, a season for the flowering of plants, and a season of rest, and without the natural rest there would be no bloom. He believed the fault of our country was to rely on fish every day in the year from whatever source it might come. There was a time for all things. Game was not shot except at the proper season, for if they did they might at once repeal the game laws, and by the end of the year there would not be a single bird left. In the same way there should be preservation of fish. Oysters were now at an almost prohibitive price in consequence of the overfishing of the beds, owing to the greater demand, and the facilities offered by railway and steamboat carriage.

Professor HUXLEY, in reply to Mr. Mackenzie, could not say he thought the distribution of ova from diseased fish was of the smallest consequence. If the ova were attacked by the disease, they would be immediately distinguished and weeded out if the most ordinary precautions were taken, whilst healthy ova had no power whatever to transmit disease.

Mr. WILMOT said it afforded him much pleasure to be able to say a word or two on this very destructive agency, which was causing so much injury to the rivers of Great Britain, *Saprolegnia ferax.* It had been his misfortune to have differed with the learned Professor on the protection of the fisheries of the world; but on this occasion he was glad to offer him his best thanks for the interesting lecture he had given on this most important disease. He felt that in this case science was doing most useful work, and hoped that by further investigation, a cure for this terrible disease would be arrived at. He believed, too, that it was only within a few years past that it had prevailed very largely in the rivers of Britain; he had been engaged in connection with fisheries for many years past, and sixteen years ago this disease was known within the small confines of the house where he was engaged in fish breeding, and his opinion, though he might be wrong, was that it was only brought about by a pollution of the water, and the increased heat occasioned by the country being cleared of its forests. This tended to bring down in the river immense quantities of infinitessimal vegetable spores, which floating down came in contact with the diseased fish, or fish which had been injured by the fishermen and others, and produced Saprolegnia. In catching these fish in the stream, in the province of Ontario, for the purpose of cultivation, it was found that many fish died from the following cause. The fish had to be caught by hand in the stream, and strict instructions were given to the men always to catch them by the tail, because, in catching them by the head the gills were always injured, and that necessarily proved fatal. The men went into the river, waded up the stream, and caught the fish on their beds at night, and at other times, in the day time, when they had their heads underneath the logs which abounded in the stream. The fishermen then carried the fish twenty or thirty rods to the house; but they invariably found, after the first or second year, that many of these fish died, the reason being that round the tail where the men had caught the fish, this peculiar sort of fungoid growth appeared, which spread until the fish was killed. This was in 1867 or 1868, before he knew anything of Saprolegnia. In order to avoid it they introduced India-rubber gloves, which had been used ever since, because they were found less likely to injure the fish. Sometimes, also, a man from hurrying or carelessness, would grab a fish across the back, leaving finger marks upon it, and in a few days after, they invariably found three or four stripes of fungoid growth appearing, and the fish invariably died. He, therefore, came to the conclusion that this fungoid growth was the result of infinitessimal spore coming down the stream, which produced this growth on the bruised portions of the fish, and the fish could not shake it off because they were generally in a prostrate and lean condition after spawning. This disease did not prevail generally in the United States, or in any other country in its natural state. Nearly all the rivers and streams, when the country was first inhabited, were pure and limpid, the waters were cold, and these immense numbers of spores did not float down the rivers; but as countries became cleared, and the volume of water reduced by absorption and evaporation, and by the superheating of the water by the sun's rays, more of these spores were produced, and when the fish were injured, as they now were by fishermen catching them, and by passing through nets, and in getting injured as they came up into the rivers, they were more liable to be attacked, and so the disease was produced. He believed there was no possibility of overcoming it until they could somehow change the waters up which the fish migrated. Another mode would be by improving the protection of those fish which could escape up the river. He might dilate on this subject, and would assure the Conference that unless some greater efforts were made to protect the fish in every possible way, they must expect them to be decimated in the end. He believed the practical remedy was to preserve fish by judicious laws, and prevent men destroying them, and also to prevent the polluted matter being allowed to flow into the stream.

Professor HUXLEY said Mr. Wilmot's remarks were very interesting and important; but there was one observation which it was necessary to make in regard to them. There was extremely good evidence that the salmon disease not only occurred, but devastated the fish in British Columbia and Northern Asia, where he need not say there was no possibility either of over-fishing or pollution.

The Marquis of EXETER then proposed a vote of thanks to Professor Huxley, and in doing so wished to refer to one or two points in connection with this fungus. He found in his own tanks and ponds, whenever they were exposed very much to the sun and intense light, the fungus had appeared more or less; he also found that in breeding salmon from some eggs sent from Canada he succeeded in raising the salmon, and they lived for about six weeks, and were apparently very healthy; but all at once this fungus began to show upon them, and, though they changed the water, nothing seemed to do them any good. He should say that the water in which he bred the fish at Burleigh was very highly impregnated with lime, so much so that kitchen boilers got choked in a very short time; and whenever they attempted to breed these salmon from ova taken from Scotland and elsewhere, after they had lived apparently well for a certain number of weeks, they invariably died of this disease. In a pond close by where there was hardly any shelter from the light, the fungus generally appeared, but it was not so where there was more shade. Latterly, however, since his present pisciculturist, Mr. Silk, had been with him, when the fungus began to show upon the fish they gave them a salt-water bath, which cured them. Some time ago he gave some black bass to the Aquarium, which did well for some time, and then the fungus appeared upon them; but as Mr. Silk was coming to London, he called there and gave them a salt bath which cured the disease, and they lived for some time afterwards; so that this fungus was quite destroyed by the administration of this bath of salt water. Of course these fish were put under the doctor directly there was the slightest sign of this dangerous disease upon them, and since then they had hardly ever lost a fish. The black bass also which came over from America in the fresh-water tanks became very seedy, and he thought that they should lose a great many, but he got some salt water out of the sea, kept them in it two days, and they all recovered and were doing well wherever they had been sent.

Sir JAMES MAITLAND seconded the motion. He had hoped that Professor Huxley would have gone very widely into the question of the diseases of fish, for they were by no means confined to the *Saprolegnia ferax.* Although perhaps of late it had occupied a large portion of the scientific research which had been bestowed on the Salmonidæ, it must be remembered that in old days when they had not the same restriction and protection they had now, although the disease was occasionally mentioned in books as the murrain among salmon, it was uncertain how far it extended. In those days the waters were frequented by otters, and there was a good deal of poaching, and he doubted if many fish that got high up the rivers ever returned into the sea, and that might account for the contradictory results obtained on the Tweed, which showed that exactly four years after the disease broke out in a virulent form the number of fish caught was much larger than before. It might be that the death of those old fish, which in descending the rivers would probably swallow a number of smolts, enabled the river to recoup itself by the growth of the young fish; and in the case of a shorter river the results might be different. In the Tweed there was a long stretch of dead water between Kelso Bridge and the sea, where celts congregated, and would very likely eat smolts nine inches long. He had just heard that this disease had reached the Don, but it was very unusual for it to break out in an almost epidemic form at this time of the year. With regard to parasites, he found that although many fish bore them they seemed to occasion very little inconvenience unless the fish were out of condition at the time. A fish exhausted or spawning was nearly always infested with parasites, and would very readily fall a victim to them.

The motion have been carried unanimously,

Prof. HUXLEY in reply said he knew nothing as to the effect of sun light, but should imagine that the elevation of temperature must play a considerable part in inducing the condition of fish which allowed it to take the disease. He had been much interested in what Lord EXETER had said respecting the limey character of the water of his district, because when this Exhibition was opened all the trout and some other fresh water fish in the new tanks with one consent began to show disease, and, that they still showed it, might be seen by the specimen on the platform taken from one of those tanks. In fact he had an opportunity of studying in the Aquarium the fungus on one of these fish, and satisfying himself that it was exactly the same thing as the salmon disease. That interested him very much in consequence of a remark made by Mr. Saville Kent who had paid considerable attention to these subjects. He said to him, as they walked round the Aquarium, that that it was a matter of course, because the water had not been allowed to run sufficiently long through the newly cemented reservoirs and tanks, and whenever that was the case the *Saprolegnia* was almost certain to make its appearance. That opened up to his mind a very interesting chapter of inquiry, though up to the present he had not been able to make any experiments in regard to it. It was very possible that any superabundance of lime in the caustic state might have a very considerable effect in bringing about the development of the disease. In the first place fungi of all kinds were extremely sensitive to small degrees of acidity and alkalinity of water, and secondly the condition of acidity and alkalinity was extremely likely, however small its extent might be, to have a very definite effect on the epidermis of the fish. This, therefore, suggested a line of investigation, which was likely to prove extremely fruitful. As to the use of salt, he believed that was an absolute remedy, and there seemed to be a consensus of opinion to that effect. Some experiments carried out by the Conservators of the Tweed showed that fish, even in an advanced stage of the disease, when cofined in cribs in tidal waters, if they did not die of the confinement, got well of the disease. Although there was one doubtful case on record of disease showing itself on fish in salt water, unfortunately the evidence that the disease was caused by *Saprolegnia* was wanting; and up to the present he had never been able to see any sufficient ground for believing that *Saprolegnia* could appear on any fish in salt water. Finally he would say one word about fish parasites. The fuss made about the parasites of fish was really very extraordinary. The lower animals, and fish especially, were not at all particular about parasites. Parasites were regularly and constantly found in particular parts of their organisms, and might rather be considered sharers of their repast than anything else, simply taking toll of whatever came in their direction. In most cases, there there was not the least evidence that these parasites had any effect on the welfare of the fish. He remembered that two or three years ago great complaints reached him from Bristol, where a large number of very fine mackerel were brought in, and the town was in an uproar, because it was said that these fish were full of parasites, and they would destroy all the good people of Bristol who ate them. Anyone who paid attention to fish must be aware that certain nematoid parasites were extremely common, but the fish were none the worse for them, and as to people catching them, in the first place they were not the same kind as those which infest man, and, secondly the fish were going to be cooked; and although the idea was not pleasant, cooked parasites *per se* were not any worse than cooked fish. As to the prevalence of parasites having anything to do with fish not being eaten at the right time of year, he did not think anyone familiar with fish would be likely to entertain that idea.

Mr. FELL WOODS then proposed a vote of thanks to the Marquis of Hamilton for his conduct in the chair, as well as for the great earnestness and energy with which he had devoted himself to the work of the Exhibition. With regard to the question of parasites, he had observed that the cockle at a certain stage abounded with a little parasite, which seemed to leave it in a perfectly healthy condition, and in no way interfered with it as an article of food if cooked, but there was this disadvantage that it did seem to interfere entirely with the fertility of the fish. The same thing occurred in the oyster in the Mediterranean.

Professor HONEYMAN seconded the vote of thanks, which was carried unanimously.

The CHAIRMAN, in responding, said they had had a most edifying discussion in connection with the various diseases of fishes. They had had the opinion of two very eminent gentlemen from Canada, and he was certain that Englishmen